

Ethanol metabolism in various racial groups

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Summary: Eskimos and Indians, according to casual reports, take longer to sober up after an alcoholic debauch than do whites. We studied this apparent difference by administering ethanol to appropriate subjects and determining blood alcohol concentrations at intervals. We found the concentrations fell significantly faster in whites. Neither previous experience of alcohol nor general diet appeared to account for this difference, leaving genetic factors as the indicated cause.

The effects of "firewater" on the native Americans have, since the days of the early explorers and traders, been described as unusually severe. More recently, accounts^{4, 5} have attested to its continuing and increasing importance as a cause of morbidity and mortality among the Indians and Eskimos of Canada.

There are unverified medical and law-enforcement reports stating that Indians jailed while intoxicated take much longer to sober up than whites in similar conditions.

In view of the alleged differences in the rates of sobering up of native and white Canadians, and of the increasing importance of alcohol consumption and its effects in our native populations, we considered that an investigation into the rate of metabolism of alcohol in such populations was indicated and undertook comparative alcohol tolerance testing.

Methods and materials

Alcohol was administered to 21 Eskimo, 26 Indian and 17 white males. Nearly half of the Eskimos were volunteers from the Inuvik district. The remaining subjects were chosen at random from among patients and staff of two Edmonton hospitals. Most of the patients were convalescing from fractures or acute infections, and provided nearly all the remaining native subjects. The whites were predominantly staff members, including students. Persons having metabolic or gastrointestinal disease were excluded, as the rate of absorption and metabolism of alcohol could be affected by such disease processes.

Liver function tests, viz. BSP retention, SGOT and alkaline phosphatase, were performed on all subjects before the alcohol tolerance tests. All had normal liver function.

The Eskimos ranged in age from 20 to 58 years with a mean of 38.5 years, were 157 to 178 cm. in height (mean 167.6 cm.) and weighed 60 to 104 kg. (mean 69.7 kg.). The Indians were from 22 to 63 years of age (mean 39.0 years), were 163 to 183 cm. in height (mean 172.5 cm.) and weighed 57 to 86 kg. (mean 68.3 kg.). The whites were from 20 to 69 years of age (mean 35.3 years), were 168 to 188 cm. in height (mean 177.3 cm.) and weighed 61 to 91 kg. (mean 75.7 kg.).

The tests were performed at 8:00 a.m. following an overnight fast. Alcohol was infused intravenously as 10% ethanol in normal saline at 10

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ml. per minute until blood levels of approximately 125 mg.% were attained. This blood level was maintained for 60 minutes and the rate of disappearance of ethanol from the blood was observed for two hours after stopping the infusion.

The blood alcohol levels were determined by use of the Breathalyzer. The Breathalyzer was standardized before testing each subject by aerating a standard solution of alcohol in distilled water through the instrument. Readings were taken every five minutes during the induction period, every 10 minutes during the maintenance period and every 15 minutes during the post-infusion period.

Calculations

If C_t is the observed concentration of alcohol in the blood at time t , then the rate of decline of this concentration, β , can be obtained from successive values of C_t .

To calculate the rate of metabolism we must take into account the general concentration of alcohol in the body. Let p be body weight and r be the proportion of the body that attains alcohol concentrations equal to those of the blood. Then, since the amount of alcohol present in the body at any time plus the amount metabolized up to that time must equal the total administered, we have

$$A_0 = (C_t + \beta.t) p.r$$

where A_0 is the total amount administered.

Since A_0 and p are known, along with β and C_t for various t , we can determine r . The rate of metabolism can then be determined, being equal to $\beta.t.p.r$.

Results

The amounts of alcohol solution infused during the tests were measured as volume per kilogram of body weight and are shown in Table I.

It can be seen from these figures that, while the volumes required for the separate stages of induction and maintenance were fairly varied, the total amounts were virtually the same for each group.

It is apparent from Table II that the rate of decline of blood alcohol level was much higher in the whites than in the natives, the rate in the whites being 0.370 mg.% per minute compared with 0.259 mg.% per minute and 0.264 mg.% per minute in the Indians and Eskimos respectively. Statistical comparison of whites and Indians gives $t = 3.98$, $P < 0.001$; comparison of whites and Eskimos gives $t = 2.74$, $P < 0.01$.

The rate of metabolism of alcohol is shown in Table IIA.

Again the Indians and Eskimos have similar figures but the whites have significantly elevated rates ($t = 4.235$, $P < 0.0005$ for whites compared to Indians; $t = 2.935$, $P < 0.005$ for whites compared to Eskimos).

To assess the influence of previous alcohol intake, the subjects were classified according to the history each one gave, as light drinkers (consuming less than 10 bottles of beer or the equivalent in other forms of alcohol per week), moderate drinkers (10 to 20 bottles of beer per week), and heavy drinkers (more than 20 bottles of beer per week). The rate of decline of blood alcohol for each resulting sub-group is shown in Table III.

The whites showed little metabolic adaptation to alcohol ingestion. Thus, the difference in the rate of blood alcohol decline in the heavy and the light white drinkers

was 0.384 mg.% per minute compared to 0.357 mg.% per minute; in comparable groups of Indians and Eskimos the rates were 0.303 mg.% per minute compared to 0.213 mg.% per minute ($t = 900$, $P < 0.001$) and 0.351 mg.% per minute compared to 0.229 mg.% per minute (no significant difference) respectively. The associated rates of metabolism are shown in Table IIIA.

These rates of metabolism are somewhat more erratic than those for decline of blood alcohol levels. There is again a discernible tendency to adaptation within each

Table I

Volume of alcohol required for induction and maintenance

	Induction	Maintenance	Total
Whites	9.47 ml./kg.	4.29 ml./kg.	13.76 ml./kg.
Indians	10.22 ml./kg.	3.75 ml./kg.	13.97 ml./kg.
Eskimos	10.49 ml./kg.	3.86 ml./kg.	14.35 ml./kg.

Table II

Rate of decline of blood alcohol levels

Whites (17)	0.370 \pm 0.127 mg. % per minute
Indians (26)	0.259 \pm 0.024 mg. % per minute
Eskimos (21)	0.264 \pm 0.011 mg. % per minute

Table IIA

Rate of metabolism of alcohol

	(g. per kg. of body weight per hour)
Whites (17)	0.1449 \pm 0.0390
Indians (26)	0.1013 \pm 0.0207
Eskimos (21)	0.1098 \pm 0.0337

Table III

Effect of previous alcoholic intake on the rate of decline of blood alcohol levels

	Whites	Indians (mg.% per minute)	Eskimos
Light drinkers	(9) 0.357 \pm 0.157	(4) 0.213 \pm 0.027	(11) 0.229 \pm 0.117
Moderate drinkers	(4) 0.377 \pm 0.145	(11) 0.233 \pm 0.027	(5) 0.254 \pm 0.081
Heavy drinkers	(4) 0.384 \pm 0.058	(11) 0.303 \pm 0.027	(5) 0.351 \pm 0.123

TABLE IIIA

Effect of previous alcoholic intake on the rates of metabolism of alcohol

	Whites	Indians	Eskimos
	(g. per kg. of body weight per hour)		
Light drinkers	(9) 0.1377 \pm 0.0459	(4) 0.0794 \pm 0.0182	(11) 0.1045 \pm 0.0336
Moderate drinkers	(4) 0.1588 \pm 0.0449	(11) 0.1027 \pm 0.0210	(5) 0.1041 \pm 0.0280
Heavy drinkers	(4) 0.1472 \pm 0.0131	(11) 0.1083 \pm 0.0167	(5) 0.1272 \pm 0.0398

ethnic group but a statistically significant trend only for Indians ($t = 2.789$, $P < 0.01$ between light and heavy drinkers).

Comparing the ethnic categories it can be noted that the similarities of Indians and Eskimos and the elevation of white rates persist. Indeed, the rate of metabolism for each category of whites is higher than that for any group of Indians or Eskimos. The rate for whites is significantly greater than the rate for Indians in each of the three classes ($t = 3.303$, $P < 0.005$ for light; $t = 2.402$, $P < 0.02$ for moderate; $t = 4.727$, $P < 0.0005$ for heavy drinkers). Other differences are of much lower significance.

Since the distinctive high protein diet of many natives was seen as a possible factor in alcohol metabolism, the native subjects were regrouped, within drinker classifications, on the basis of high protein diet (50% or more of the calories were derived from fish and meat) versus high carbohydrate (CHO) diet, (i.e. a diet similar to the average white Canadian diet with less than 50% fresh meat). Using these groupings, the decline in blood alcohol levels in the natives is shown in Table IV.

According to these figures, dietetic differences do not produce a significant effect on the rate of decline of blood alcohol levels. For both light-drinking and heavy-drinking natives a high carbohydrate diet correlates with higher rates of decline of blood alcohol levels (0.212 mg.% per minute as compared to 0.147 and 0.317 mg.% per minute as compared to 0.298, respectively). However, in the moderate-drinking group of natives the situation is reversed; those on a high protein diet lower their blood alcohol more rapidly than those on a high CHO diet, the rates being 0.274 mg.% per minute and 0.210 mg.% per minute respectively. The rate of metabolism of alcohol in the natives when classified according to dietetic differences is shown in Table IVA.

Table IV
Effect of diet on the rate of decline of
blood alcohol levels in the natives

	High protein diet (mg. % per minute)	High CHO diet (average Canadian diet)
Light drinkers	(4) 0.147 \pm 0.114	(10) 0.212 \pm 0.024
Moderate drinkers	(5) 0.274 \pm 0.024	(12) 0.210 \pm 0.054
Heavy drinkers	(4) 0.298 \pm 0.020	(12) 0.317 \pm 0.030

Table IVA
Effect of diet on the rate of metabolism
of alcohol in the natives

	High protein diet (g. per kg. of body weight per hour)	High CHO diet (typical Canadian diet)
Light drinkers	(4) 0.0770 \pm 0.0297	(11) 0.1053 \pm 0.0301
Moderate drinkers	(5) 0.1016 \pm 0.0127	(11) 0.1039 \pm 0.0238
Heavy drinkers	(4) 0.1247 \pm 0.0324	(12) 0.1107 \pm 0.0245
All	(13) 0.1011 \pm 0.0319	(34) 0.1067 \pm 0.0256

Here, again, there is a suggestion that a high carbohydrate diet increases the rate of metabolism, but the indications are erratic and without statistical significance.

Discussion

Widmark⁷ found the slope of the disappearance curve of blood alcohol to be 0.015% per hour and the function to be linear. This average was substantiated by Gradwohl,⁸ who found that the rate varies considerably among individuals. In 1943, Goldberg¹ found that heavy drinkers metabolize alcohol up to 25% more rapidly than abstainers, but later² found that the rate of disappearance of alcohol was not significantly different in the two groups.

Shumate, Crowther and Zarafshan⁶ found the disappearance curve to be linear in form and constant in that there is no relation between the amount of alcohol in the blood and its rate of disappearance. They also state that the rate of disappearance in the same individual at different times is constant, and suggest that people have a characteristic burning rate. They found that the average rate of metabolism of alcohol was 0.015% per hour in males and 0.0185% per hour in females.

There was no significant difference in the amount of alcohol infused into the members of our various groups to bring the blood alcohol levels up to desired height and to maintain them there (Table I).

In our series the rate of fall of blood alcohol among the whites is significantly greater than in either the Indians or Eskimos, viz. 0.370 mg.% per minute as compared to 0.259 mg.% per minute and 0.264 mg.% per minute. The rate of fall within the various native population samples is not significantly different and, in fact, may be considered equal (Table II).

Also, the rate of metabolism of alcohol amongst the whites is significantly greater than in either the Indians or Eskimos, viz. 0.1449 g. per kg. per hour as compared to 0.1013 g. per kg. per hour and 0.1098 g. per kg. per hour, and there is no significant difference between rates for the two native population samples (Table IIA).

Classification of the natives according to drinking habits revealed a preponderance of heavy and moderate drinkers among our Indian population when compared to the whites and Eskimos (Table III). The whites consisted largely of volunteers from the hospital staff and of medical students and was weighted with persons having little or no past experience with alcohol. This was also the case in the Eskimo population.

In each ethnic group a tendency to adaptation to alcohol was indicated, but only among the Indians was this significant. Expressed in terms of rate of decline of blood alcohol level (Table III) the rate for Indians increased from 0.213 mg.% per minute for light drinkers to 0.303 mg.% per minute for heavy drinkers; in terms of rate of metabolism (Table IIIA) the increase was from 0.0794 to 0.1083 g. per kg. per hour. This greater adaptation among Indians may be due to greater alcohol intakes by their heavy drinkers than by the similarly classified whites.

Despite this general tendency for metabolic adaptation to higher alcoholic intakes, i.e. heavy drinkers metabolize alcohol faster than light drinkers or non-drinkers, even the sub-groups of heavy drinkers among the natives had lower rates of metabolism than the sub-group of light-drinker whites.

The smallness of the ethnic/alcohol sub-groups prompts caution in these interpretations of adaptation.

Vallee⁸ suggested that racial differences in alcohol

tolerance are related to variations of alcohol dehydrogenases in liver and other organs. Cammack⁹ demonstrated elevated dehydrogenase activity in herbivores compared with carnivores. However, we were unable to demonstrate any significant difference in alcohol metabolism between the natives on high carbohydrate diets and those on high protein diets. Our grouping was based on dietary habits followed during the last 10 to 20 years only, so excluded any influence of genetically fixed variations in enzymatic activities that reflected the traditional protein-rich diet of the natives.

Conclusions

Indians, Eskimos and whites require comparable amounts of alcohol per unit of body weight to achieve intoxicating blood levels, but the natives metabolize alcohol at a significantly slower rate than the whites.

The difference is not due to experience with alcohol or dietary protein/carbohydrate balance of the individuals concerned. It is probably due to genetic differences which may, in turn, be due to differences in diet over many generations.

The finding of a lower rate of metabolism of alcohol in Indians and Eskimos may have important practical application in health education and preventive medicine in view of the fact that the effects of alcohol abuse have become a pre-eminent health problem in native Canadians.

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Résumé

Le métabolisme de l'alcool éthylique chez divers groupes raciaux

D'après certains rapports fortuits, les Esquimaux et les Amérindiens mettent plus de temps à se dégriser que les blancs après d'être envirés. Nous avons étudié cette différence apparente en donnant de l'alcool éthylique à des volontaires appartenant aux races susdites et en dosant la teneur du sang en alcool à divers intervalles. Nous avons alors noté que la baisse de la concentration sanguine se produisait plus vite chez les blancs. Ne pouvant incriminer ni le régime alimentaire, ni l'habitude de l'alcool pour expliquer cette différence, les auteurs concluent qu'il doit s'agir de facteurs génétiques.

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- méthode a l'avantage de pouvoir comparer le transit rénal de l'agent utilisé avec son transit dans la grande circulation, par exemple dans l'aorte.
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